

# DARPA Thermal Ground Plane

## Engineered Nanostructures for High Thermal Conductivity TGP Substrates

GE Global Research

GE Fanuc

Univ. of Cincinnati

AFRL

### Project Team



**GE Global Research**

TGP Modeling & Design,  
Nano Surface Texturing,  
Packaging, Thermal and  
Reliability Testing



**GE FANUC**

Embedded Systems  
Next-Generation  
Military Products



**Air Force  
Research  
Laboratory**

Thermal & High-g Testing



**University of  
Cincinnati**

Heat Pipe Design and  
Benchtop Experiments



imagination at work

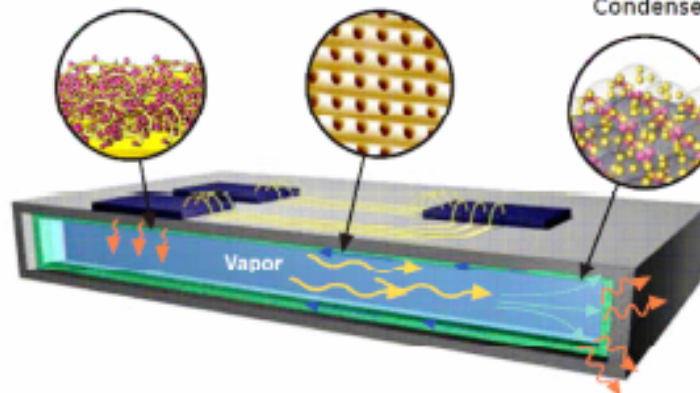
### 3-Phase Program to Develop Engineered Nanostructures for High Thermal Conductivity Substrates

**Program Objective:** Demonstrate TGP board capable of 20,000 W/m-K to enable high heat flux electronics for military applications under high-g operation.

Nanostructured  
Superhydrophilic  
Evaporator

Nanostructured  
Superhydrophilic  
Wick

Nanostructured Hybrid  
Superhydrophobic/  
Superhydrophilic  
Condenser



#### Technical Approach

- Develop multiphase flow computational models
- Tailored nanostructured surfaces
- Integration of evaporator, wick, and condenser in TGP envelope

#### Technical Challenges

- Multiscale, multiphase thermo-fluid models
- Self-assembly of site-specific nanosurfaces
- Hermetic sealing
- TGP system integration

#### Relevant Prior Work

- Nanoengineered surfaces
- GE superhydrophobic/superhydrophilic nanostructured surface heat transfer for evaporation and condensation
- Over 30 years of electronics packaging experience
- Physics-based multi-phase flow computational modeling

#### Program Deliverables

- Demonstration of nanostructured TGP with thermal conductivity of 20,000 W/m-K and reliable operation at 20g acceleration

#### Anticipated Benefits of the Proposed Technology

- 100 × thermal conductivity over common copper alloy backed substrates
- Unprecedented power dissipation
- TGP enables many military and commercial applications
- TGP design is transparent to end-user

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